ExcelPlas Independent Materials Testing

ACCELERATED STRESS CRACK METHOD FOR HDPE GEOMEMBRANES (2019)

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1. INTRODUCTION

Stress Crack Resistance (SCR) testing of HDPE geomembranes has been conducted for a number of years using ASTM D5397 which describes the Single-Point Notched Constant Tensile Load (SP-NCTL Method). This test is long in duration (e.g. 400 to 1000 hours typically) and uses surfactant chemicals (Igepal™) which must be specifically sourced and disposed of in a responsible manner. The preparation of the test specimens requires they be prepared very carefully, very accurately notched to 20% of their thickness in a exacting manner that must be precise and reproducible. The test is very sensitive to notch blade sharpness, water bath temperature, degree of mineralization of the water diluent, concentration of the surfactant, degree of micellization of the surfactant and the age of the surfactant in longer term tests.

ExcelPlas has researched alternative and more rapid methods for determining the SCR of HDPE geomembranes. In particular a promising, predictive method for rapidly determining the SCR of HDPE liners using the strain hardening modulus (SHM) obtained by an Elevated Temperature tensile testing (ETTT) has been published by the following researchers:

M. McCarthy, R. Deblieck, P. Mindermann, R. Kloth, L. Kurelec and H. Martens (https://www.researchgate.net/publication/253304530) describe a method where geomembrane sheet was milled and compression moulded into a thin sheet (0.3 to 1.00 mm thick). ISO 37 type 3 tensile test specimens were punched from the sheet. The specimens were tensile tested at 10mm/min. at a temperature of 80°C where strain hardening occurred during the testing process. A linear correlation was found between the strain hardening modulus and the NCTL time to failure for the material.

H. Zanzinger and K. Engelsing, (https://www.researchgate.net/publication/297731785) applied the same testing methodology but used specimens punched directly from the geomembrane sheets. They also found a correlation between the strain hardening modulus and the NCTL time to failure for their samples (see relationship below).

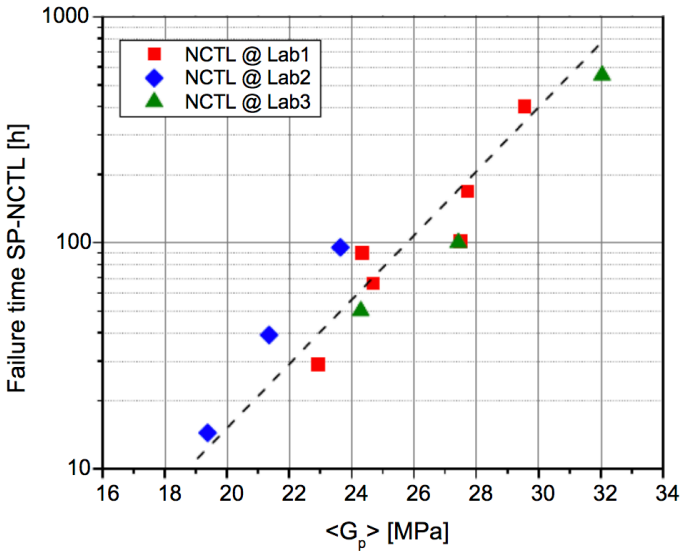


Figure 4. Strain hardening modulus <Gp> versus SP-NCTL failure times for different HDPE geomembranes

***Source**: "A new accelerated test method for stress crack resistance of HDPE geomembranes" by Helmut Zanzinger & Kurt Engelsing*

Presented at GeoAmericas 2012, At Lima.

In this present in-house study ExcelPlas used the strain hardening modulus (SHM) obtained by the Elevated-Temperature Tensile Testing (ETTT) to determine the stress crack resistance (SCR) of various geomembrane liner (GML) samples and correlates the SHM data with regular NCTL SCR data.

2. EXCELPLAS INVESTIGATIONS

ExcelPlas attempted to reproduce the outcomes of the above investigations using the published methods. Retained samples of geomembrane liner samples from actual jobs that had been tested for SP-NCTL were reanalysed using the principles and method described by McCarthy et. al. and Zanzinger and Engelsing.

2.1 Materials and Sample Preparation for Tensile Measurements

Six HDPE geomembranes of varying SP-NCTL failure time values were subjected to strain hardening modulus testing. The specimens were punched out of the geomembrane sheet using an ASTM D5397 die. The length of the specimen was 60mm with the length of the narrow section being 13mm and the width of the narrow section 3.20mm. All specimens were cut in the transverse direction from 2mm thick sheet.

2.2 Tensile Measurement and Strain Hardening Data

The specimens were tested using a specialized tensile test procedure on a Shimadzu AGS-X universal testing machine equipped with a 2kN load cell. This tensile tester has a very high level of detection and precision required for these measurements. Extensometric measurements were undertaken using a Shimadzu TRXViewX Video Extensometer. The entire testing was conducted within Shimadzu TCE-N300 Series Thermostatic Chamber. Prior to testing the specimens were kept for at least 30 minutes in the test chamber to allow for thermal equilibration.

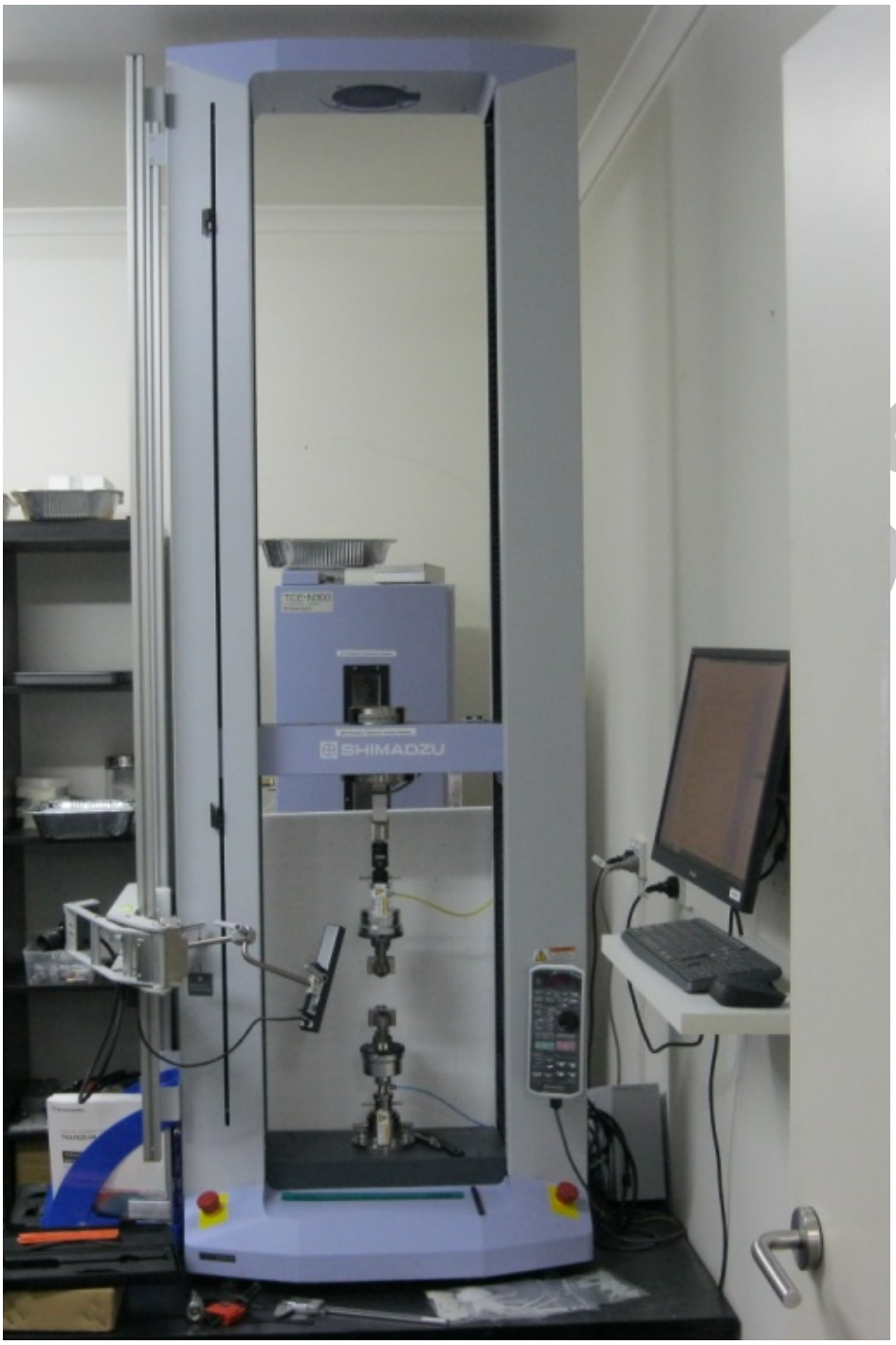


Figure 1. Shimadzu AGS-X Universal Testing Machine with Elevated Temperature Enclosure at ExcelPlas Labs.

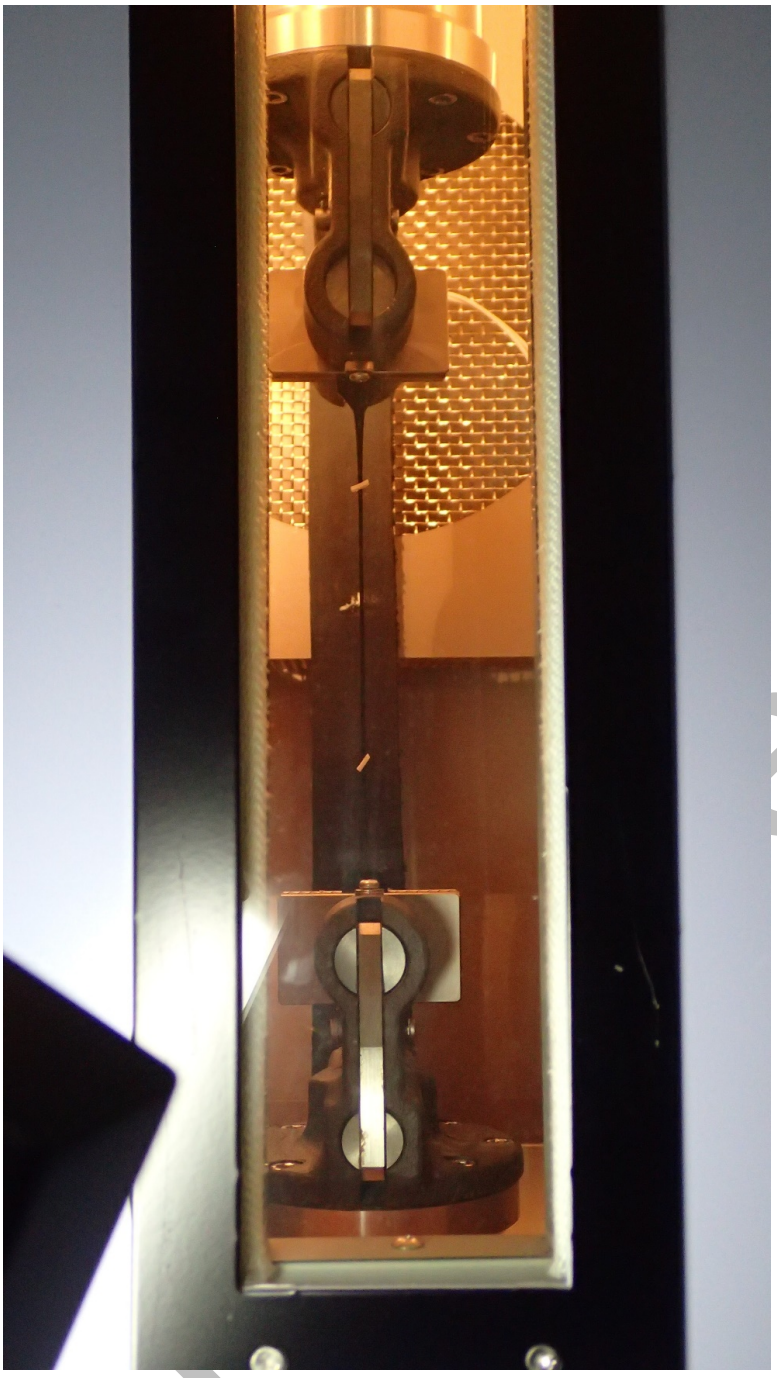


Figure 2. Tensile specimen under test in 80 deg.C thermostatted environmental temperature enclosure for the Elevated Temperature Tensile Test.

3. SCR METHOD by SP-NCTL and SHM

Notched Constant Tensile Load (NCTL) tests were performed according to ASTM D5397 as a single point test. The tests were carried out using the standard ASTM D5397 conditions of a stress level of 30% of the tensile strength at yield at room temperature. The bath reagent was 10% Igepal CO630 at 50°C in demineralized water. Five replicates were done for each geomembrane sample.

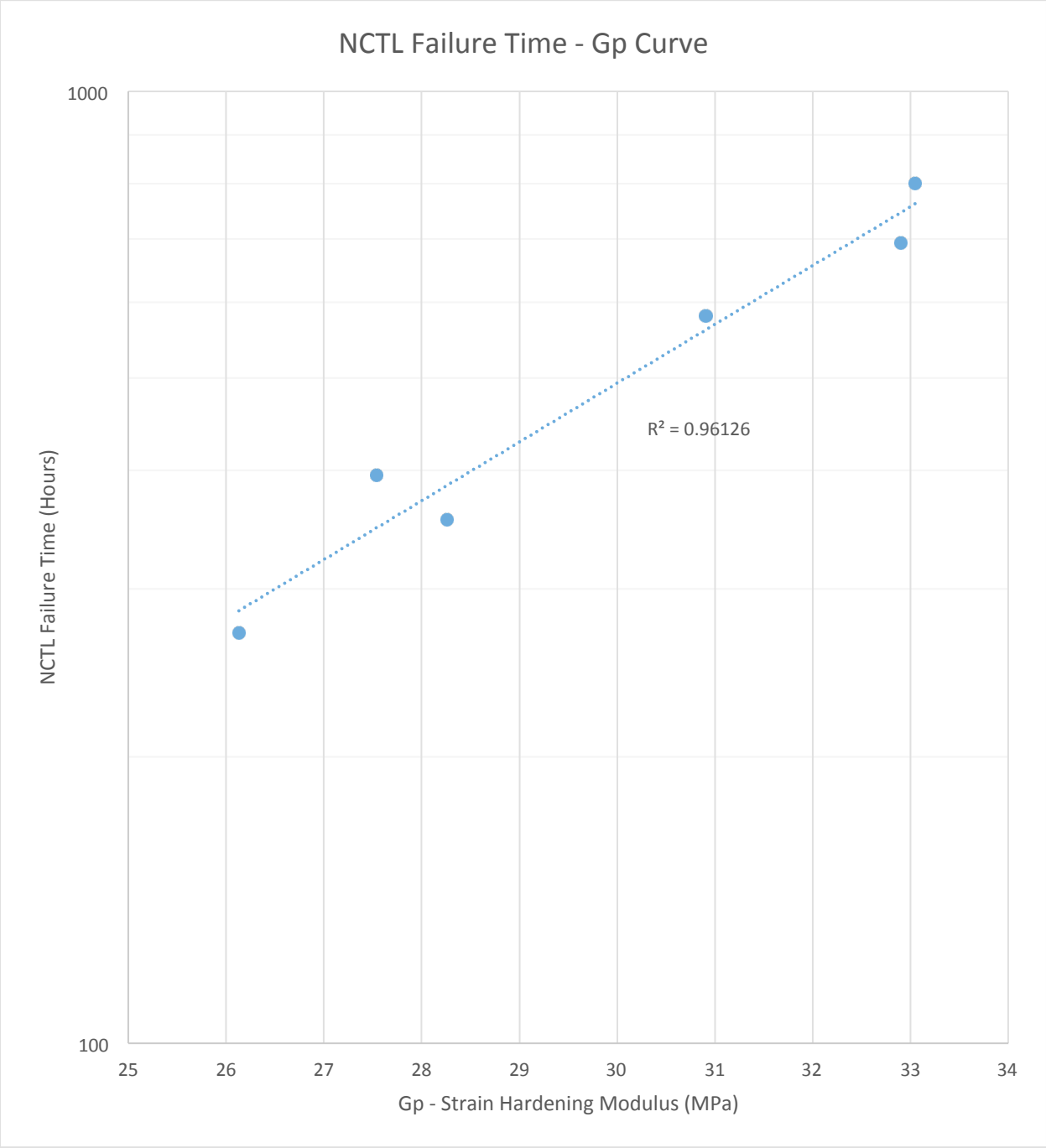
Figure 3. NCTL-SCR specimens under test in 50 deg.C thermostatted Igepal™ bath.

Strain hardening modulus (SHM) testing was performed using an elevated tensile test method as described by McCarthy et. al and Zanzinger/Engelsing at 80 deg.C.

4. RESULTS

The comparison of results are shown below:

Sample No.	Sample Identification	**SP-NCTL Failure Time (hrs)**	**<Gp> Strain Hardening Modulus by ETTT (MPa)**
1	# 2820 RN803539003 270hrs	270	26.13
2	# 7014 RN846509194	355	28.26
3	# 5411 #6 Layflat W+C	395	27.54
4	# 5411 #3 GSE W&C	581	30.91
5	# 5411 #8 GSE W&C New	693	32.90
6	# 5411 #7 GSE High Performance	800	33.05



Correlation curve for NCTL Failure Time versus Strain Hardening Modulus (SHM) by Elevated-Temperature Tensile Testing (TT) (as produced by ExcelPlas Labs).

5. CONCLUSIONS

This testing study has shown there is a very good correlation (R^2 = 0.963) between the strain hardening modulus (SHM) as performed using an elevated temperature tensile test (ETTT) at 80 deg.C and the traditional single-point, notched constant tensile stress crack resistance (SP-NCTL SCR) measurements performed using the standard Igepal™ solution immersion at 50 deg.C.

The strain hardening modulus (SHM) method has been found to be quick, easy and reliable compared to the NCTL test. ExcelPlas intend to offer the SHM method to the geomembrane industry as a fast and predictive test for determine the stress crack resistance (SCR) of HDPE geomembrane liner (GML) samples.